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ABSTRACT

A protective coating for a substrate is disclosed having an outer component or module formed of a swellable material and an inner module formed of a plurality of layer or bilayers formed of ceramic material. The coating comprising a plurality of modules comprising a first module comprising a number (m) of bilayers comprising zirconia and alumina wherein (m) is a number greater than 1. The coating further comprises a second module disposed on the first module comprising a number (n) of bilayers comprising zirconia and titania wherein (n) is a number greater than 1. The coating further comprises a third module disposed on the second module comprising a third-module compound capable of forming a hydrate or hydroxide compound upon contact with an oxygen containing environment.